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A new method for measuring the spectral irradiance at LNE-Cnam

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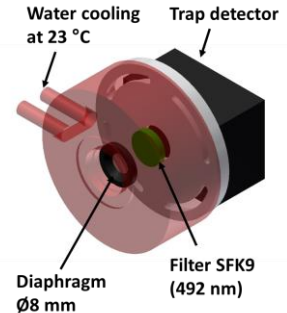
Since, French primary spectral irradiance scale was linked to the thermodynamic temperature reference. Measurement range was from 300 nm to 2500 nm.

A new method for measuring the spectral irradiance of a source has been developed. This **facility is based on the comparison of a source to be calibrated with a high temperature blackbody (HTBB)**. The reference spectral irradiance is determined by measuring the temperature of the HTBB with a filter radiometer. To minimize uncertainties, corrections on temperature homogeneity and emissivity of HTBB are applied.

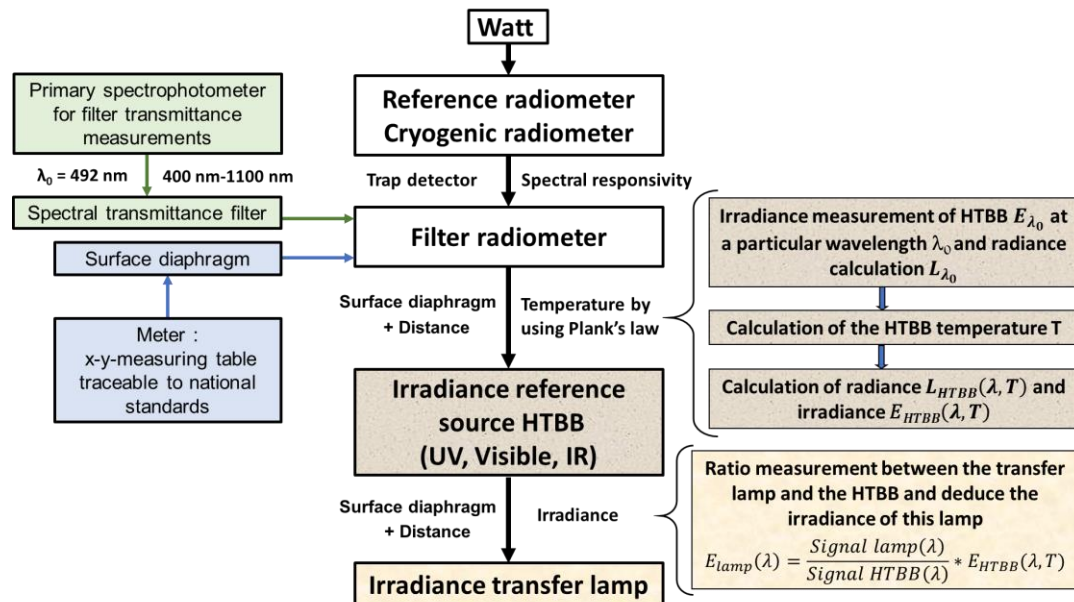
The **filter radiometer** is based on a silicon 3 photodiodes trap detector. Its spectral responsivity is obtained in 3 steps :

- calibration of spectral responsivity of the trap detector against our cryogenic radiometer
- calibration of the spectral regular transmittance of its bandpass filter with our primary spectrophotometer
- calibration of diaphragm surface with our devoted setup.

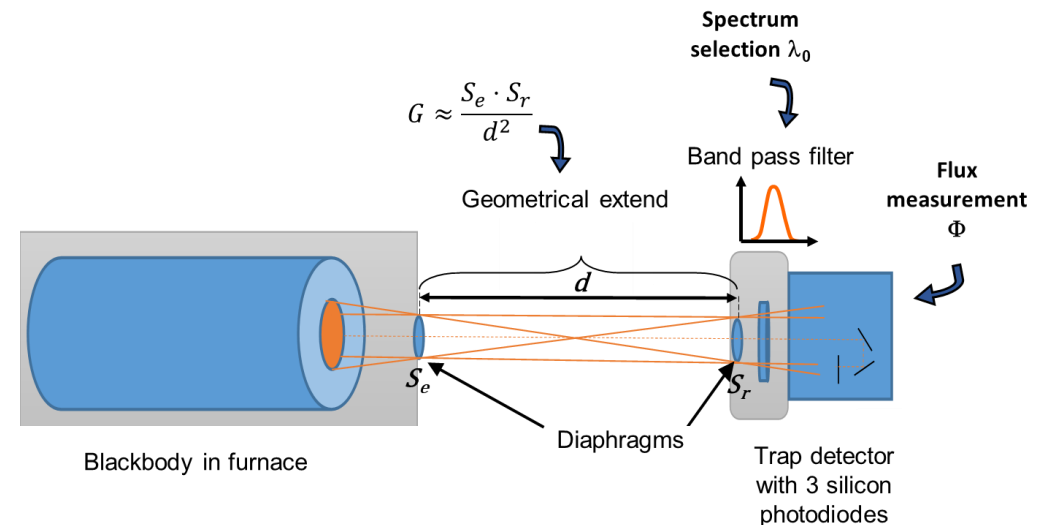
As the reflectivity of the trap detector is null, the flux responsivity of the radiometer is the product of the filter transmittance by the detector responsivity.



New method and traceability scheme



Measurement irradiance reference principle



Experimental setup

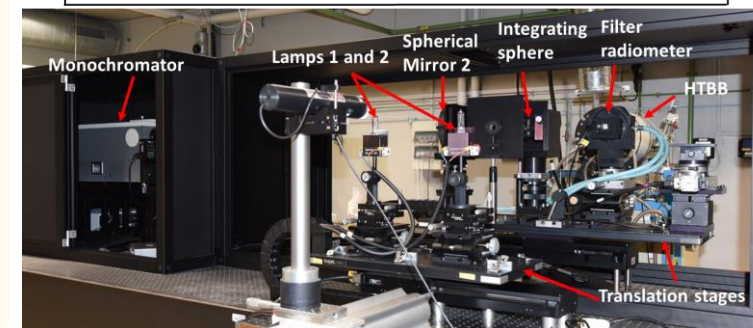
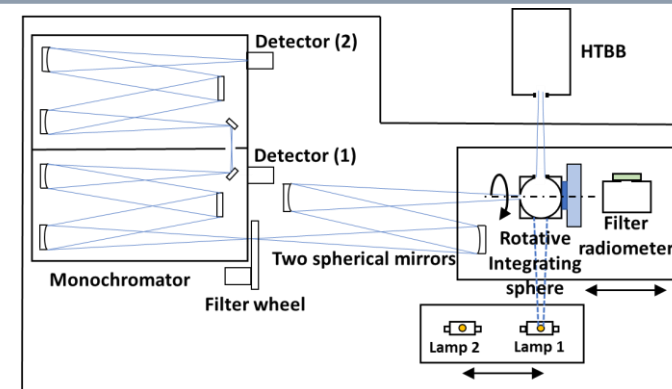
* A HTBB equipped with a 8 mm diameter diaphragm is heated up to 3000 K. It provides radiations that can be used in the 250 nm to 2500 nm range.

* A spectroradiometric system compares the spectral irradiance of HTBB and transfer lamps. It is composed of :

- an integrating sphere equipped with a circular entrance port diaphragm to receive the flux from the sources and with a rectangular slit shape of 2 mm x 15 mm output port located at 90°
- two Ø 150 mm spherical mirrors that focus the image of the sphere exit slit on to the entrance slit of a double monochromator
- a Jobin Yvon HRD double monochromator on which the manual wavelength selection mechanism has been replaced by a high precision motorized translation stage and equipped with three gratings to cover the spectral range
- different detectors to be used depending on application area (photomultiplier(2), Si photodiode(1), InGaAs photodiode(1) or IR enhanced InGaAs photodiode(1)).

* A calibrated filter radiometer with a responsivity centered on 492 nm.

The filter radiometer and the integrating sphere are placed on the same translation stage to perform in one cycle the HTBB temperature measurement and the spectral irradiance ratio of the HTBB and the lamps.
The integrating sphere is rotated by 180° around the axis centered on the exit slit to collect either the HTBB or the transfer lamps flux.
Entire spectroradiometric system is placed in a box with two compartments, one for the detection part and one for the monochromator, in order to avoid stray light. The bench is fully automated and controlled by a custom LabVIEW software.



Validation

Our set of 4 reference transfer lamps have been measured and compared with their historical values on the range 300 nm to 2500 nm. There is at least **a factor two between historical and new measurement uncertainties** (k=2) over the entire range.

Wavelength (nm)	Relative expanded uncertainty (k = 2) / (%)	
	2016	2019
250		7.2
260 - 290		3.0 - 1.4
300 - 310	3.9	1.2
320 - 390	2.6	1.0 - 0.85
400 - 1400	2.2	0.39 - 1.8
1500 - 2300	2.6	0.37 - 1.2
2400 - 2500	5.0	2.3 - 7.5

Most of the mean deviations 2019/2016 observed are smaller than the expanded uncertainty of the comparison. At 300 nm, the significant deviation observed seems to correct the deviation that we had during the last CCPR K1-a in 2005. It could be explained by lack of flux and the stray light of former simple monochromator.

Wavelength (nm)	Mean deviation 2019/2016 (%)	Comparison uncertainties 2019/2016 (k=2) / (%)
300	4.5	4.1
320 - 380	0.35 - 1.3	2.8
400 - 1050	0.010 - 0.59	2.3 - 2.9
1100 - 2200	0.061 - 2.6	2.3 - 2.8
2300 - 2500	4.6 - 8.4	2.9 - 9.0

Conclusion

From now on, **LNE-CNAM spectral irradiance reference is based on the radiometric reference**. Thanks to the new setup, it is possible to measure the spectral irradiance of transfer lamps with a direct traceability to our cryogenic radiometer.
Our **measurement capacity is extended to cover the spectral range from 250 nm to 2500 nm**.
Our **measurement uncertainties are reduced by at least a factor two over almost the entire range**.

In the future, this measurement setup can be improved by using LabSphere scatterers (Spectralon and Infragold) instead of integrating sphere for :

- ⇒ an extension of our measurements up to 200 nm
- ⇒ an extension of our measurements up to 3000 nm.